System-Wide Evaluation and Planning Tool (SWEPT)

Operational Concept Description

February 28, 2003

Prepared for
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Preface

This report was developed from the referenced documents in order to conform to the required contents of an Operational Concept Description (OCD) as jointly defined by National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) Free Flight Project Office. The majority of the descriptive material has been taken from the referenced documents available at the time of publication. Modifications have been made to add sections not in previous concept descriptions, to improve readability, and to reflect the most currently available information.

This approach to the development of this document was taken in order to remain faithful to the efforts that are presently being undertaken by the NASA Advanced Air Traffic Technologies (AATT) Project Office, the Tool Developers and the associated NASA AATT contractors.

This document was prepared by Titan Systems Corporation, 700 Technology Park Drive, Billerica, MA under Contract Number NAS2-98005. It represents CDRL #3.a.2 of Research Task Order 72 “AATT Operational Concept Description for Air Traffic Management Year 2002 Update”.

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1. Scope

This Operational Concept Description (OCD) of the System Wide Evaluation and Planning Tool (SWEPT) is intended to provide enough detail to form a basis for further research into the concept. The OCD has a focus of operational and system requirements, and deliberately avoids design information to the extent possible. Specifications are omitted from this document, since capabilities to support the SWEPT should evolve as a result of the research to be conducted. This OCD has the following objectives:

It provides technical transfer and sharing of information within the NASA research community. It is intended to capture the current thinking of NASA researchers concerning the future air traffic management (ATM) environments and capabilities that may be created by this concept.

It is a guide for a planned program of research in this concept. It is consistent with It is consistent with the Advanced Air Traffic Technologies (AATT) Operational Concept for Air Traffic Management (Reference 1).

1.1 Identification

This document applies to the System Wide Evaluation and Planning Tool.

1.2 System Overview

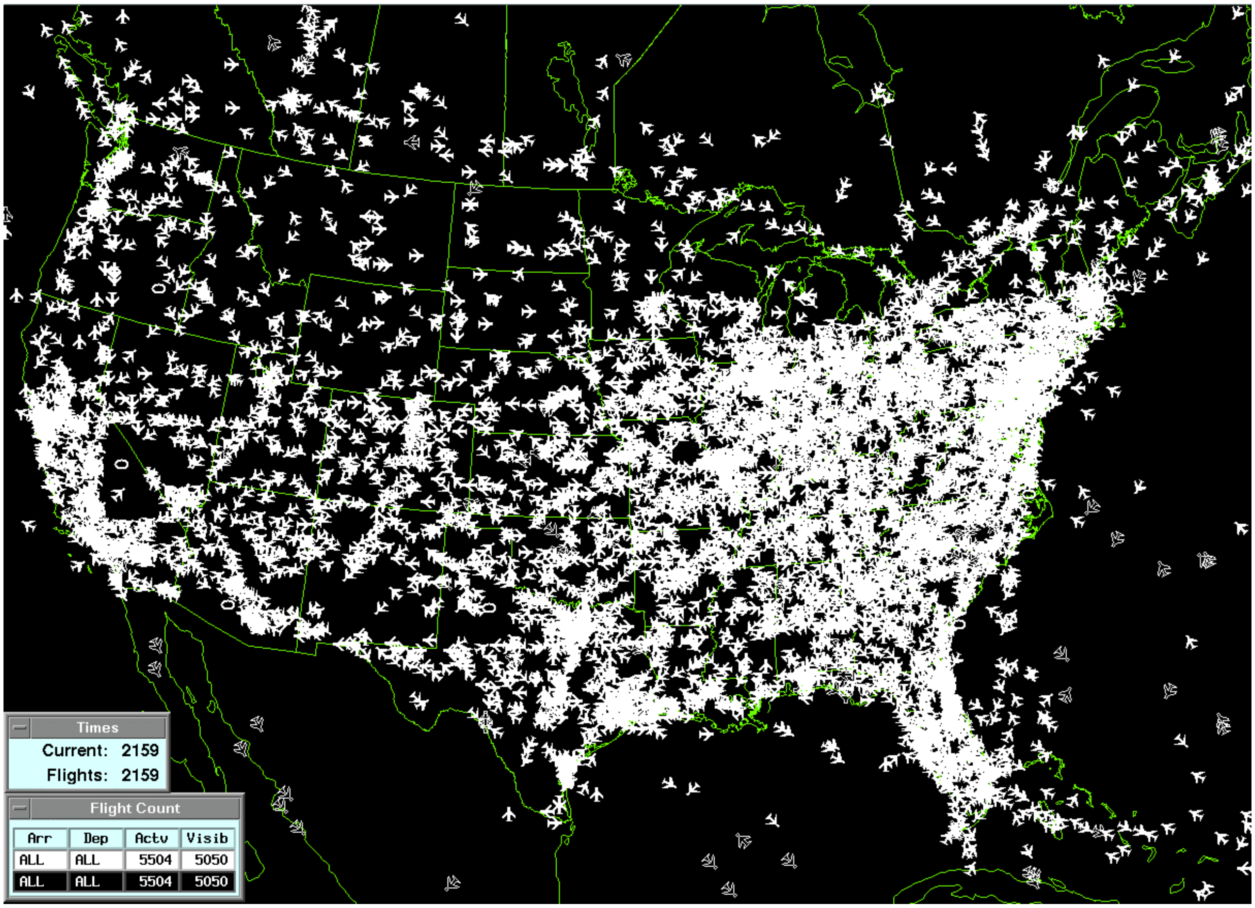
Purpose: The purpose of SWEPT is to provide additional national and local traffic flow management (TFM) capabilities that can be integrated into current FAA TFM tools.

General Nature of the System: Air traffic management is the strategic management of traffic flow to minimize delays and congestion while maximizing the overall "throughput" of the National Airspace System (NAS). The goal of TFM is to provide strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace. The air traffic management system must balance safety requirements with capacity and the demand for services that result from increased air traffic. Automation is a key ingredient for this improvement as it will enhance air traffic control and traffic management performance in the face of ever increasing traffic loads.

History of System Development, Operation, and Maintenance: There are from 4,000 to 6,000 aircraft operating in the NAS during peak periods. This equates to approximately 50,000 aircraft operations per day. Figure 1 shows over 5,000 aircraft operating in the system at one time. There are an additional 10,000 aircraft that are scheduled to depart in the next 5 hours that also need to be factored into NAS flow planning decisions.

The role of the Air Traffic Control System Command Center (ATCSCC) is to manage this flow of air traffic within the continental United States. The ATCSCC has been operational since 1994 and is located in one of the largest and most sophisticated facilities of its kind.

Figure 1. Aircraft in Flight on Typical Day



There are many support components that aid in the successful balance of air traffic demand with system capacity. The ATCSCC regulates air traffic when weather, equipment, runway closures, or other impacting conditions place stress on the NAS. In these instances, Traffic Management Specialists at the ATCSCC take action to modify traffic demands in order to remain within system capacity. This is accomplished in cooperation with airline personnel, Traffic Management Specialists at affected facilities, and air traffic controllers at affected facilities. During the severe weather season in the summer, there are severe weather specialists who deal with the impacts of storms during this period. Additionally there is a quality assurance group within FAA responsible for determining if an initiative performed as well as expected.

Key milestones in this evolution of traffic management automation systems have been:

- Mid - 1980s: Enhanced Traffic Management System (ETMS) developed as prototype by the Volpe National Transportation Systems Center
- 1988 – 1992:Operational ETMS fielded on Apollo workstations at ATCSCC, Air Route Traffic Control Centers (ARTCCs), and Terminal Radar Control Facilities (TRACONS)
- 1994: Apollo workstations replaced with HP 9000/433s

- 1994: ETMS software converted from Pascal to C
- 1995: Collaborative Decision Making (CDM) initiated.
- 1999 – Present: TFM systems added

Project Sponsor, Acquirer, User, Developer, and Maintenance Organizations: The NASA AATT Project is the sponsor of SWEPT; the developers are the NASA Ames Research Center. FAA personnel at the ATCSCC are working closely with NASA to define the desired/required capabilities for SWEPT. If all or parts of SWEPT are put into the operational traffic flow management system, the FAA will be the acquirer, user, or maintenance organization

Current and Planned Operating Sites: The primary location of the FAA's air traffic management system is the ATCSCC located near Washington, D.C. In addition, ATCSCC coordinates the actions of traffic management units (TMUs) located in ATC facilities across the country. Nationwide, there are 20 ARTCCs. Each ARTCC contains a TMU that is responsible for traffic flow within that Center's designated airspace. Traffic Management Coordinators (TMCs) at Centers, TRACONS, and towers employ a combination of automation decision support tools and procedures to facilitate efficient traffic management.

Other Relevant Documents: Documents relevant to the SWEPT concept are found in Section 2.

1.3 Document Overview

The AATT NAS OCD (Reference 2) documents current research and to provide concept guidance for all AATT projects. It was designed with the understanding that each project element would require a separate OCD of a subset or domain in the NAS in which a particular deficiency is addressed. This OCD is intended to provide guidance for SWEPT requirements development, to address how SWEPT fits into the overall NAS, and to provide a means to help transfer this technology to the FAA.

This document is organized according to a format based on the IEEE J-STD-16-1995 standard. Descriptions of the OCD sections follow.

Section 1. Scope: This section contains a full identification of the system to which this OCD applies. It briefly states the purpose of the system; describes the general nature of the system; summarizes the history of system development, operation, and maintenance; identifies the project sponsor, acquirer, user, developer, and maintenance organizations; identifies current and planned operating sites; summarizes the purpose and contents of this document; describes any security or privacy protection considerations associated with its use; and lists other relevant documents.

Section 2. Referenced Documents: This section lists the number, title, version, date, and source of all documents referenced in this OCD.

Section 3. Current System/Situation: This section describes the background, mission, objectives, and scope of the current system/situation including applicable operational policies and constraints and a description of the current system/situation. The description includes, as applicable:

- The operational environment and its characteristics
- Major system components and the interconnections between these components
- Interfaces to external systems or procedures
- Capabilities/functions of the current system
- Charts and accompanying descriptions depicting input, output, data flow, and manual and automated processes
- Performance characteristics, such as speed, throughput, volume, and frequency
- Quality attributes, such as reliability, maintainability, availability, flexibility, portability, usability, and efficiency
- Provisions for safety, security, privacy protection, and continuity of operations in emergencies

In addition, a description of the types of users or personnel involved in the current system is included. This section also provides an overview of the support strategy for the current system.

Section 4. Justification for and Nature of Change: This section describes new or modified aspects of user needs, threats, missions, objectives, environments, interfaces, personnel, or other factors that require a new or modified system. It summarizes deficiencies or limitations in the current system that make it unable to respond to these factors. All new or modified capabilities/functions, processes, interfaces, or other changes needed to respond to these factors are summarized in this section. In addition, this section identifies priorities among the needed changes; changes considered but not included; the rationale for not including them; and, any assumptions and constraints applicable to the identified changes.

Section 5. Concept for a New or Modified System: This section describes the background, mission or objectives, and scope of the new or modified system and any applicable operational policies and constraints and a description of the new or modified system. The description includes, as applicable:

- The operational environment and its characteristics
- Major system components and the interconnections between these components
- Interfaces to external systems or procedures
- Capabilities/functions of the new or modified system
- Charts and accompanying descriptions depicting input, output, data flow, and manual and automated processes
- Performance characteristics, such as speed, throughput, volume, and frequency
- Quality attributes, such as reliability, maintainability, availability, flexibility, portability, usability, and efficiency
- Provisions for safety, security, privacy protection, and continuity of operations in emergencies

- In addition, a description of the types of users or personnel involved in the new or modified system is included. This section also provides an overview of the support strategy for the new or modified system.

Section 6. Operational Scenarios: This section describes one or more operational scenarios that illustrate the role of the new or modified system, its interaction with users, its interface to other systems, and all states or modes identified for the system.

Section 7. Summary of Impacts: This section describes anticipated operational, organizational, and development impacts on the user, acquirer, developer, and maintenance organizations.

Section 8. Analysis of the Proposed System: This section provides a qualitative and quantitative summary of the advantages, disadvantages, and/or limitations of the new or modified system. Major system alternatives, the tradeoffs among them, and rationale for the decisions reached are also provided.

Section 9. Notes: This section contains general information that will aid the reader's understanding of this OCD. It includes an alphabetical listing of all acronyms and abbreviations and their meanings as used in this document, and a list of terms and definitions.

Section 10. Annexes: These are used to provide information published separately for convenience in document maintenance. Each annex is referenced in the main body of the OCD where the information would normally have been provided.

2. Referenced Documents

1. Anon, *AATT Operational Concept for ATM Year 2002 Update (AATT02),* Advanced Air Transportation Technologies (AATT) Project, September 2001.
2. Anon, *AATT National Airspace System Operational Concept Description,* Advanced Air Transportation Technologies (AATT) Project, January 2003
3. Usmani, A., *TFM System Description*, FAA AUA-740 Presentation, October 2002.
4. Anon, *FAA Air Traffic Control System Command Center National Severe Weather Playbook*, November 2002.
5. Anon, *FAA Order 7210.3S; Facility Operation and Administration*; August, 2002
6. Anon, *FAA Order 7110.65N,* Air Traffic Control; August, 2002
7. Anon, *DOD Order 7610.4J; Special Military Operations,* July 2001

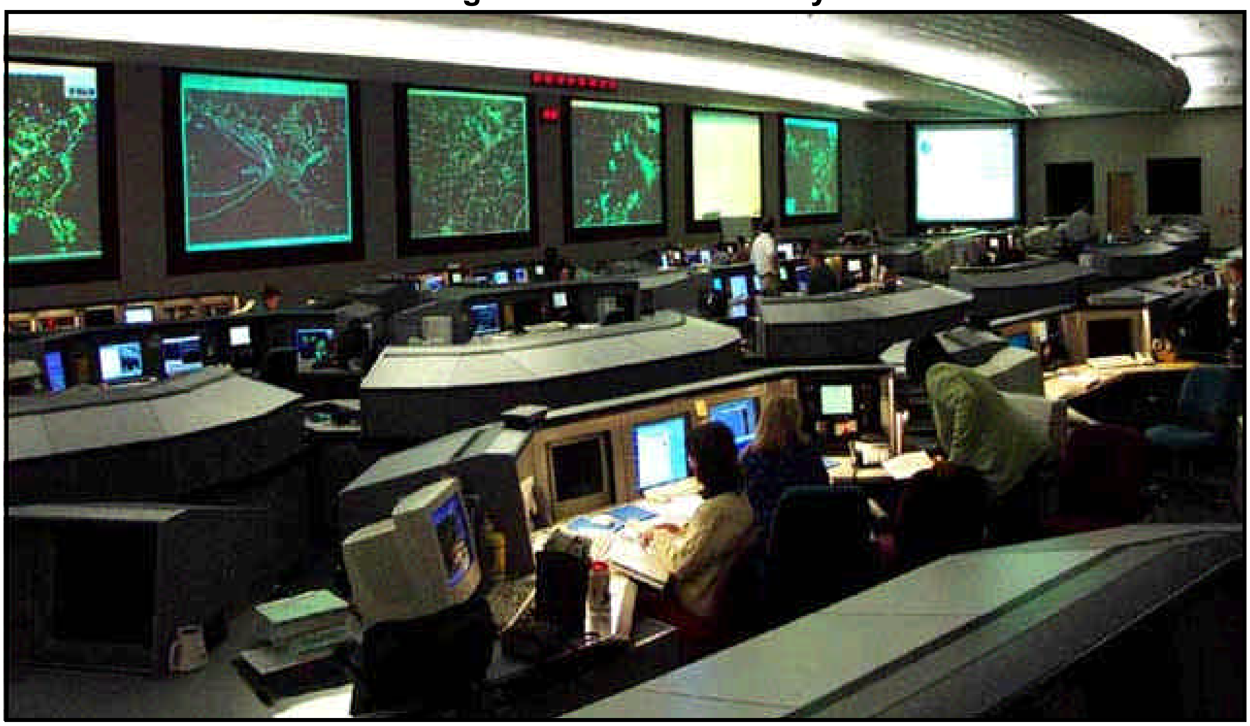
3. Current System/Situation

3.1 Background, Objectives, and Scope

Air traffic management is the strategic management of traffic flow to minimize delays and congestion while maximizing the overall "throughput" of the NAS. The goal of TFM is to provide strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace. The air traffic management system must balance safety requirements with capacity and the demand for services that result from increased air traffic. Automation is a key ingredient for this improvement as it will enhance air traffic control and traffic management performance in the face of ever increasing traffic loads.

Leading the FAA's air traffic management team is the ATCSCC located near Washington, D.C. and shown in Figure 2.

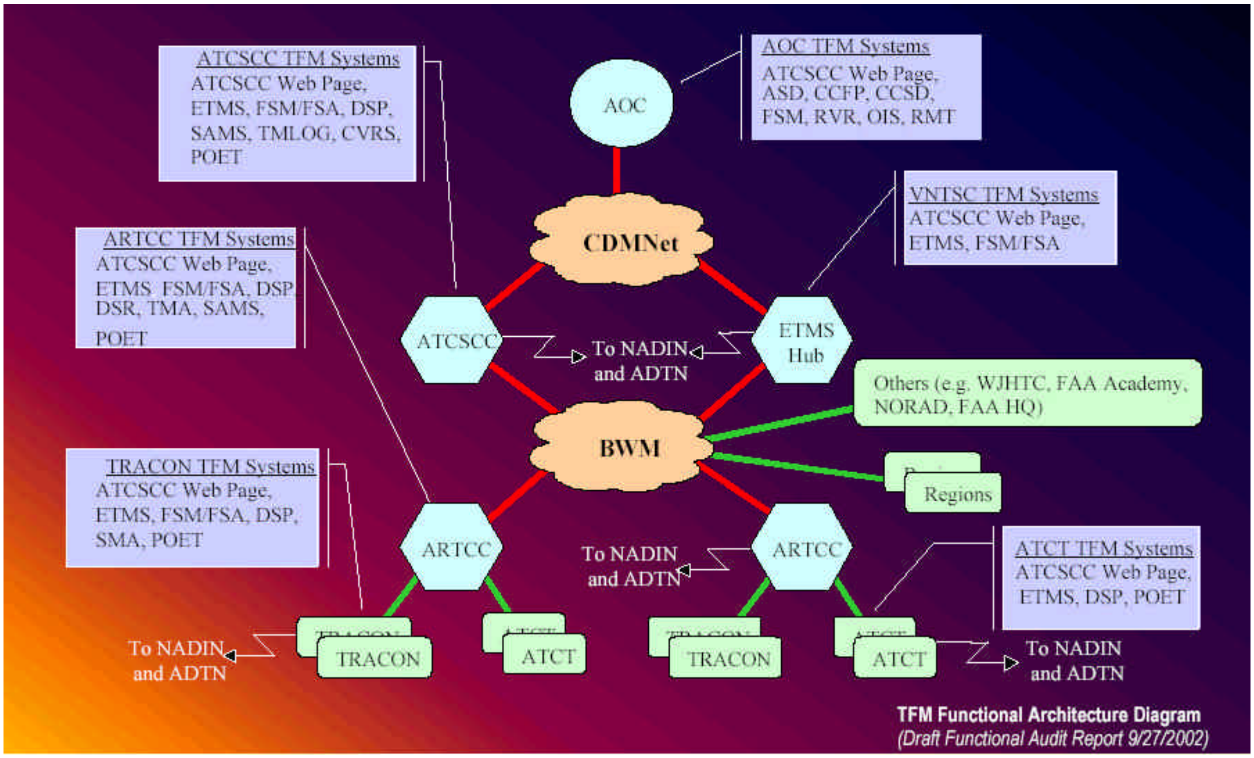
Figure 2. ATCSCC Facility



The ATCSCC manages air traffic problems with a national perspective. In addition, ATCSCC coordinates the actions of TMUs located in ATC facilities across the country. Nationwide, there are 20 ARTCCs. Each ARTCC contains a TMU that is responsible for traffic flow within that Center's designated airspace. TMCs at Centers, TRACONS, and towers employ a combination of automation decision support tools and procedures to facilitate efficient traffic management. The ATCSCC regulates air traffic when weather, equipment, runway closures, or other impacting conditions place stress on the NAS. In these instances, Traffic Management Specialists at the ATCSCC take action to modify traffic demands in order to remain within the system's capacity.

Today's traffic management system (TMS) evolved over several decades and is designed to meet the demands and requirements of the traveling public. A block diagram of the current TFM communications architecture is shown in Figure 3 (Reference 3).

Figure 3. TFM Communications Network



The core of the TFM infrastructure is the ETMS which:

- Supports and integrates an array of software tools that provide common situational awareness of current and forecast NAS conditions.
- Distributes planning among major NAS users and managers, and
- Provides performance analysis of traffic management operations to identify and resolve problems in the NAS and identify areas for improvement.

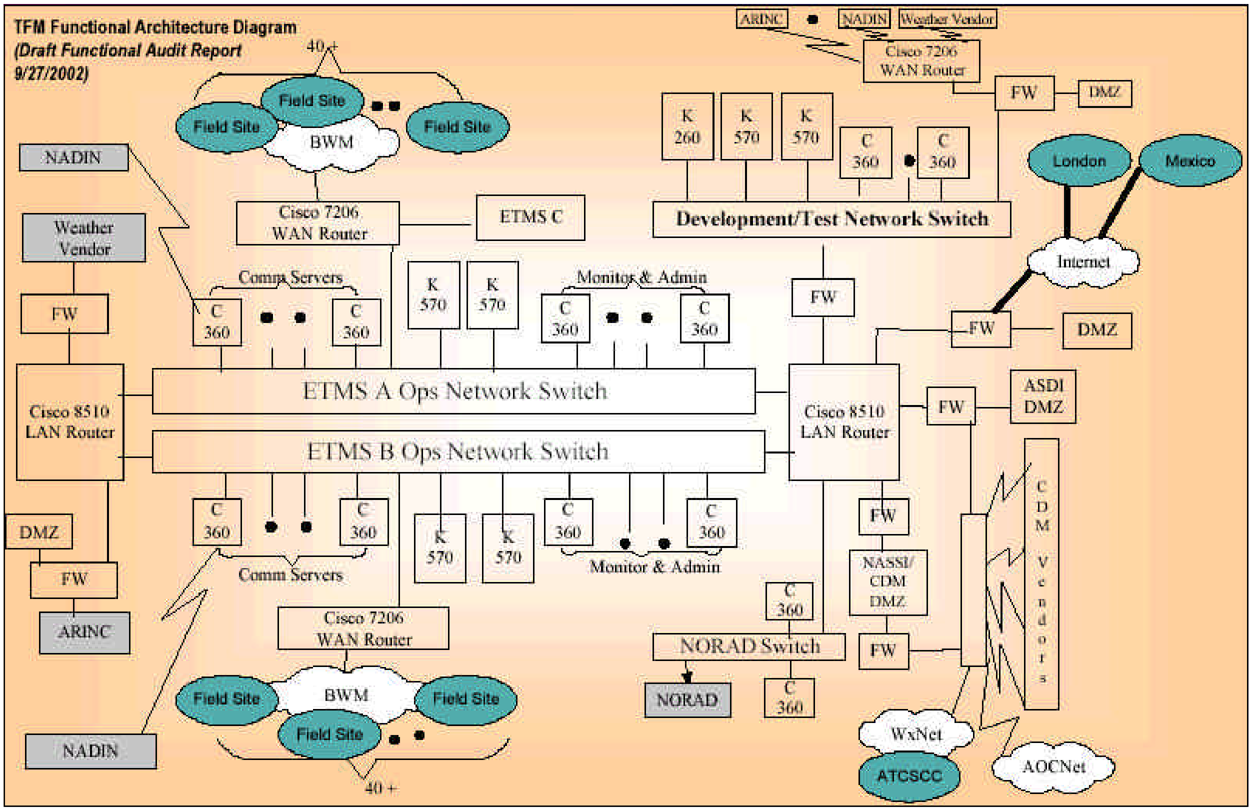
A block diagram of the current ETMS network is shown in Figure 4 (Reference 3).

ETMS significantly improve the efficiency of air traffic management. ETMS automation assists traffic managers in alleviating congestion, reducing delays, and avoiding traffic flow problems nationwide. The ETMS is an operational system interfacing people, equipment and procedures.

ETMS is the system used by Traffic Management Specialists to predict, on national and local scales, traffic surges, gaps, and volume based on current and anticipated airborne aircraft. Traffic Management Specialists evaluate the projected flow of traffic into airports and sectors then implement the least restrictive action necessary to ensure that traffic demand does not exceed system capacity.

ETMS supports traffic managers in measuring traffic demand by showing, on a national scale, current traffic surges, gaps, and volume. It also predicts the flow of air traffic up to 4 hours in advance. Thus, a traffic manager can access destinations, see the projected flow into specific airports or sectors, and take action to ensure that traffic demand does not exceed system capacity for that certain airport or sector.

Figure 4. ETMS Network



Key TFM functions include:

- Enhanced data exchange
- Improved arrival/departure management
- Improved congestion management
- System impact assessment
- Performance assessment

Enhanced Data Exchange

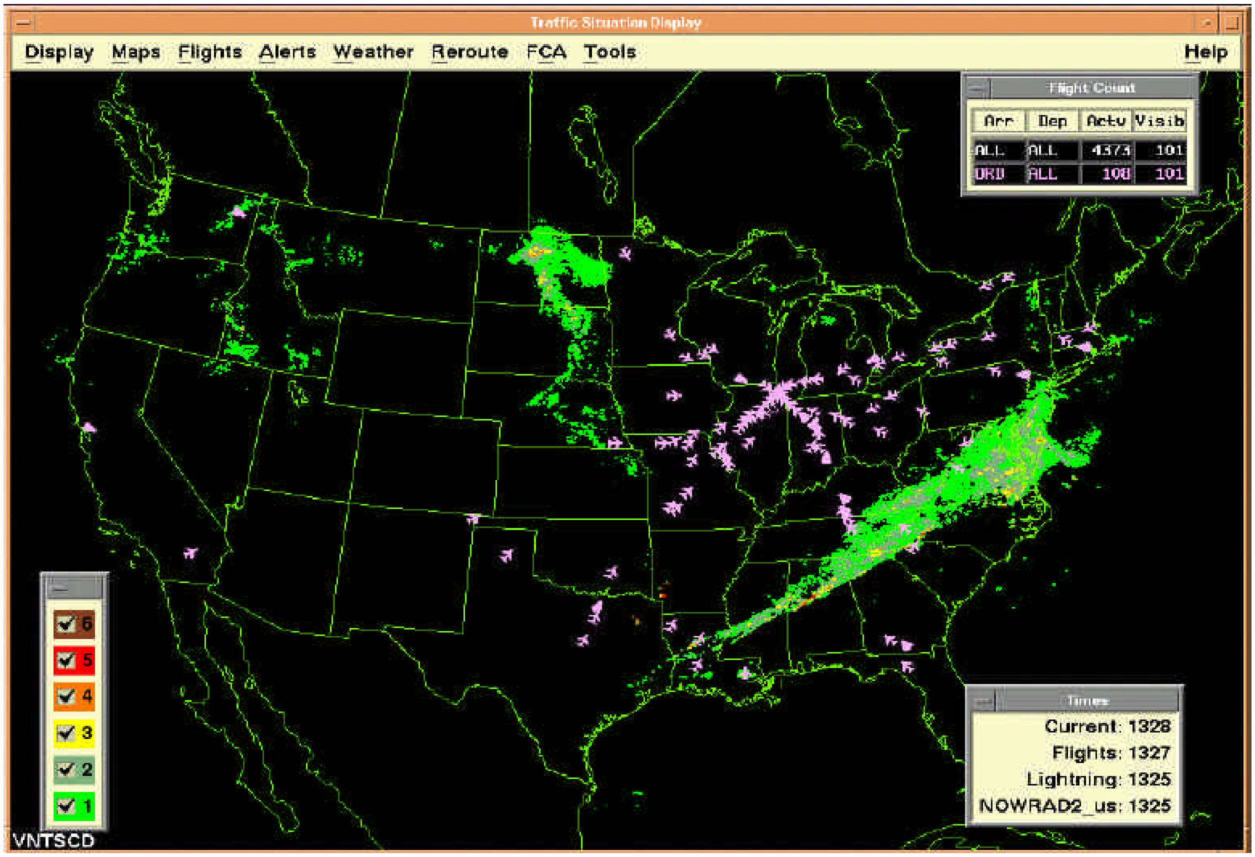
Enhanced data exchange facilitates a common situational awareness of NAS operations through an established network between the FAA and NAS users. A number of data exchange tools have been developed to support this function. They include:

- Traffic Situation Display (TSD) as shown in Figure 5.

  TSD graphically displays current aircraft positions on a national scale superimposed on maps of geographical boundaries or NAS facilities. It displays all Instrument

Flight Rule (IFR) aircraft and other flights tracked by the 20 Centers. The TSD user can select numerous methods of filtering to highlight groups of aircraft since the system can display all known flights simultaneously or filter out all but a selected group of flights. Aircraft fly on a network of airways. Below 18,000 feet mean sea level (MSL), these are called Victor airways. At and above 18,000 feet MSL, they are designated Jet routes. The TSD can display these complex networks to assist flow management and aircraft routings.

Figure 5. Traffic Situation Display



- Graphically displays current aircraft positions on maps with geographical boundaries
- Traffic can be viewed in a variety of modes – national, regional, and local airport
- Displays weather features affecting air traffic.

Other data exchange tools include:

- Web-Based Situation Display (WSD)
- Common Constraint Situation Display (CCSD)
- Runway Visual Range (RVR)
- Collaborative Convective Forecast Produce (CCFP)
- Diversion Recovery Web Page (DRWP)
- Enhanced Status Information System (ESIS)

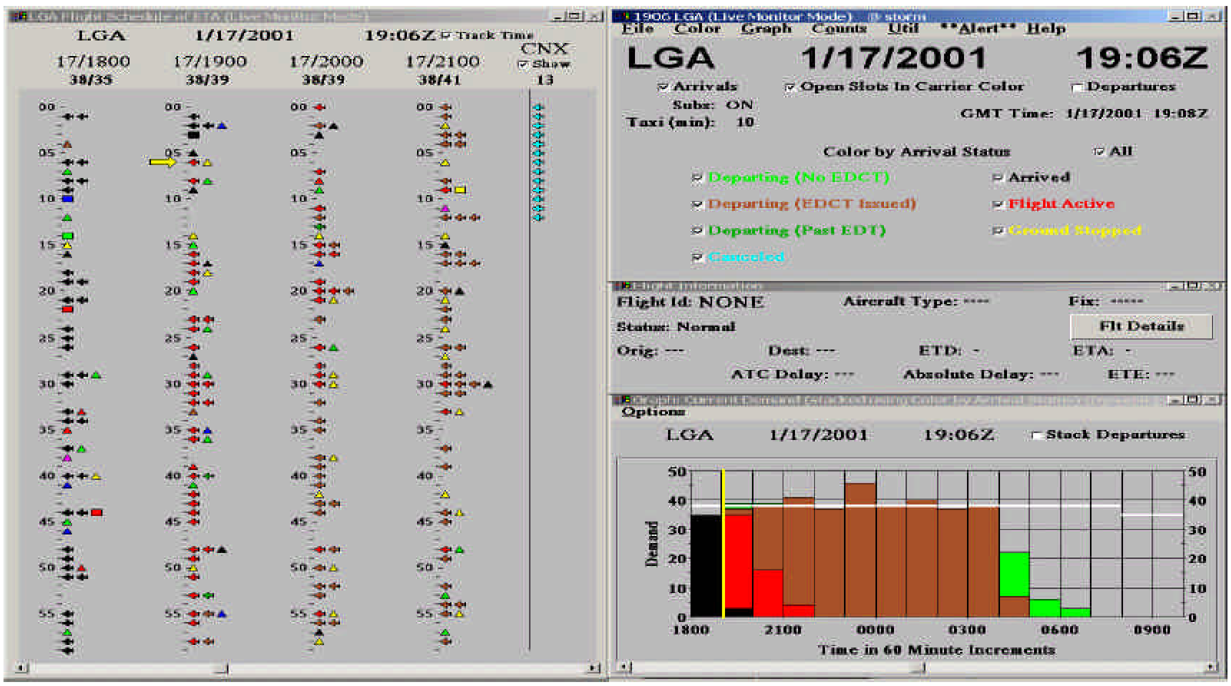
· Traffic Management Log (TM Log)

Improved Arrival/Departure Management

A number of technologies and procedures have been implemented to enable the FAA and NAS users to optimize the airport operation for both arrival and departures. These include:

- Flight Schedule Monitor (FSM) as shown in Figure 6.
  - Allows Airline Operations Centers (AOCs) and ATCSCC to view graphical and timeline displays of airport capacity and demand
  - Includes several rationing schemes that try to balance capacity and demand efficiently and equitably
  - Runs on NT-based platform independent of ETMS

Figure 6. Flight Schedule Monitor



Other arrival/departure management tools include:

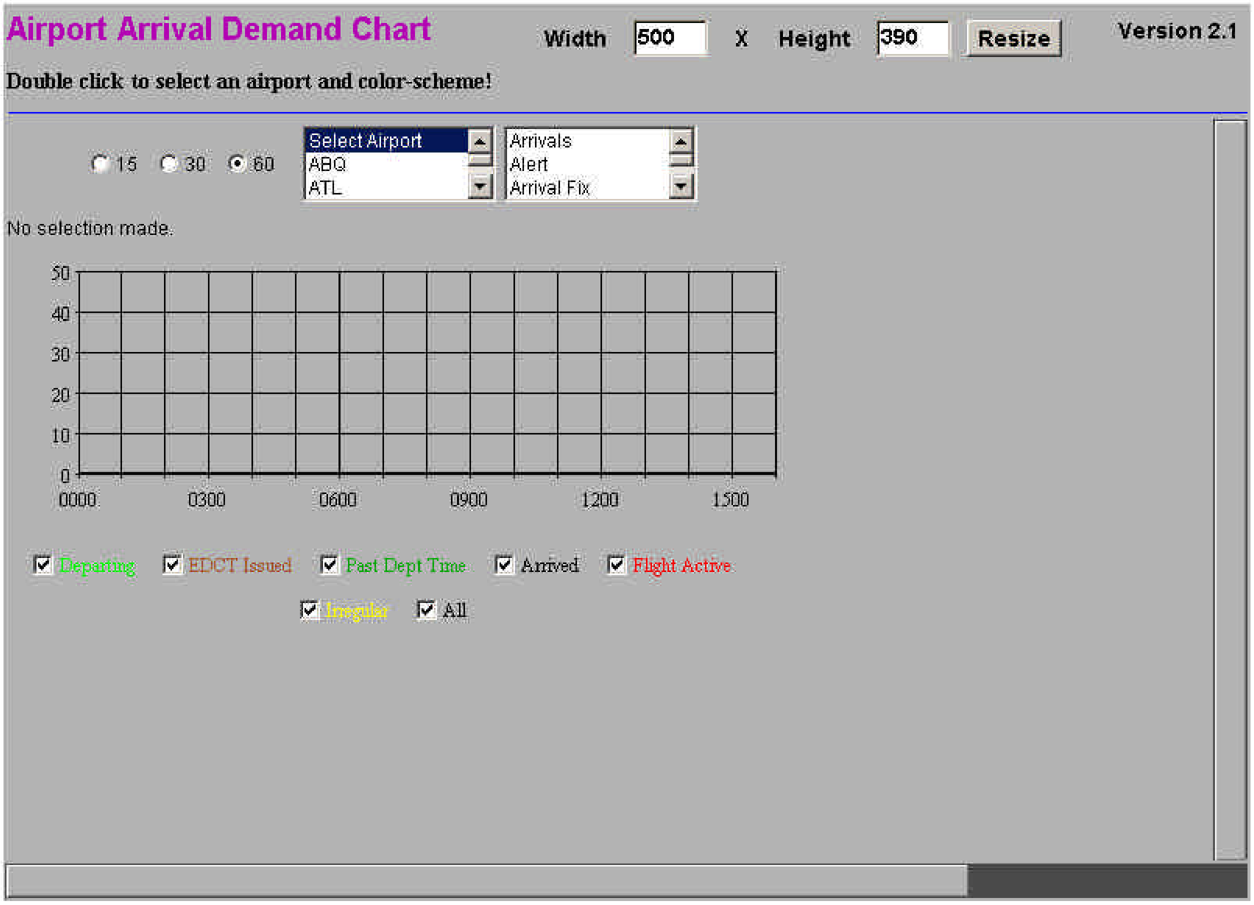
- Ground Delay Programs (GDPs)
- Flight Schedule Analyzer (FSA)
- Airport Demand Chart (ADC) as shown in Figure 7
- Departure Spacing Program (DSP)

Improved Congestion Management

Improved congestion management provides the ability to forecast airspace congestion, measure and communicate forecast uncertainty, and execute planned TFM initiatives. Congestion management tools include:

· Monitor Alert (M/A) as shown in Figure 8.

Figure 7. Airport Arrival Demand Chart



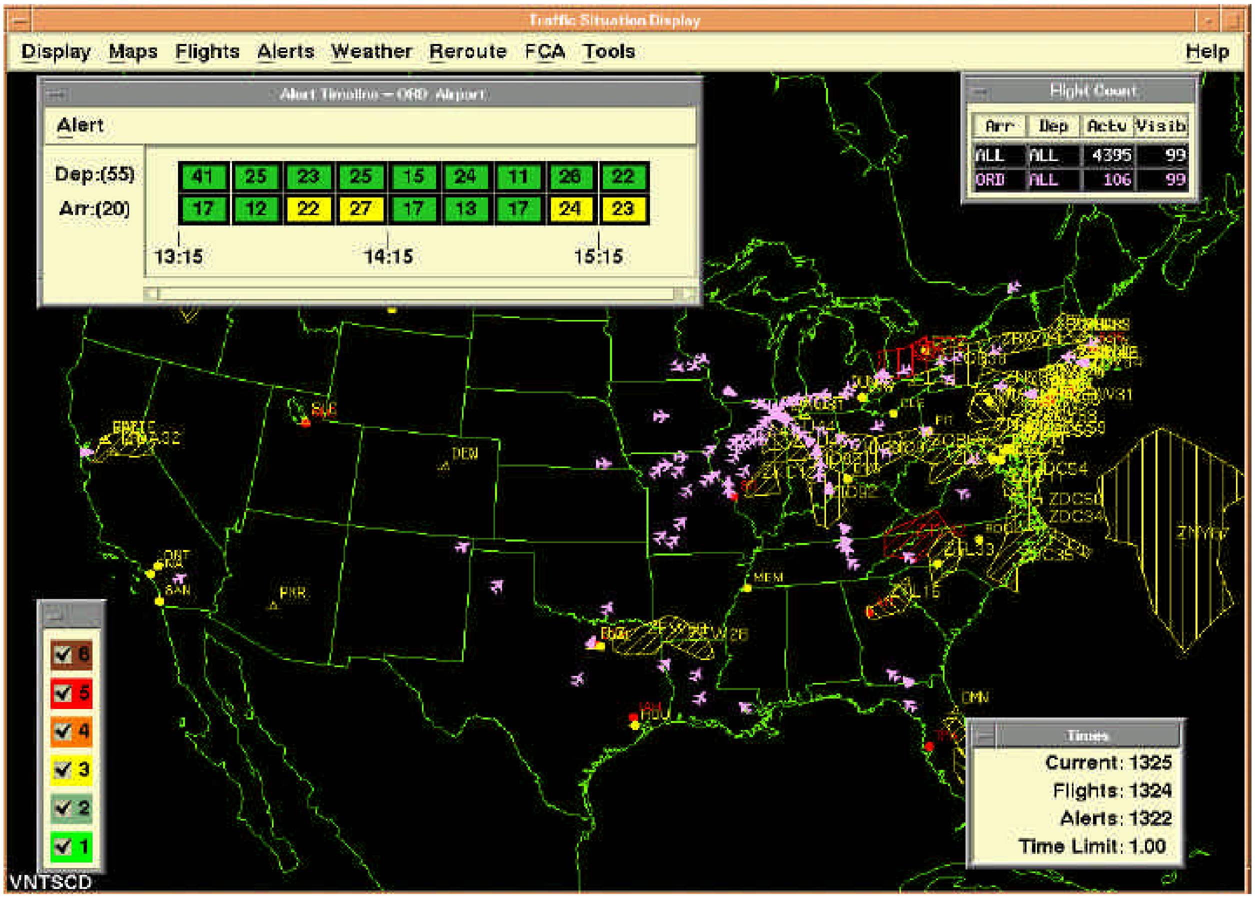
The M/A function, available through TSD, is central to ETMS. It compares demand to capacity. M/A analyzes traffic demand for all airports, sectors, and airborne reporting fixes in the continental United States. M/A then automatically displays an alert when demand is predicted to exceed capacity in a particular area.

M/A is able to project traffic demand for all airports, sectors, and fixes of interest in the continental United States. It then automatically generates alerts when the projected demand exceeds capacity thresholds. Alerts are provided in visual and aural form.

Predictions are in 15 minute increments for up to 4 hours into the future. An alerted sector can be isolated and enlarged on the map to display the predicted congestion in greater detail. Traffic management coordinators can review predicted traffic levels and time intervals of concern which are displayed graphically by red and yellow bars representing actual and predicted traffic volume.

If the traffic management coordinator needs more information, lists of all concerned flights, along with their locations and intended flight paths, can be displayed. This new ETMS function assists traffic managers in pinpointing potential traffic problems so they can take action to reduce or eliminate congestion on the airways.

Figure 8. Monitor Alert



Monitor-Alert provides the traffic management coordinator with a four-step process to display the predicted situation on the TSD screen. First the United States, or any selected area, can be viewed to identify the existing and predicted alert sectors or airports. These are displayed as red (active alert) or yellow (projected alert). The projected alert indicates that the demand is projected to exceed the capacity. Once an alert area has been addressed, the alert color changes to green.

The second step in the process identifies the value of the alert. The screen displays a graphic bar chart that allows the controller to visualize the value of the alert as well as provide the number of aircraft that exceed the capacity. The chart shows green for the capacity of the sector or airport, yellow for the proposed, and red for the active alert. Time is displayed in 15 minute increments.

The traffic management coordinator can then display all of the flights that make up the alert or those projected flights that will cause the demand to exceed the capacity. This allows the traffic management coordinator to visualize the problem, spacing, and routes to assist in establishing the necessary flow control.

Traffic management coordinators may also display a printed report of the aircraft that are affecting the alert which further assists them in their decision making process.

- Common Constraint Situation Display (CCSD)

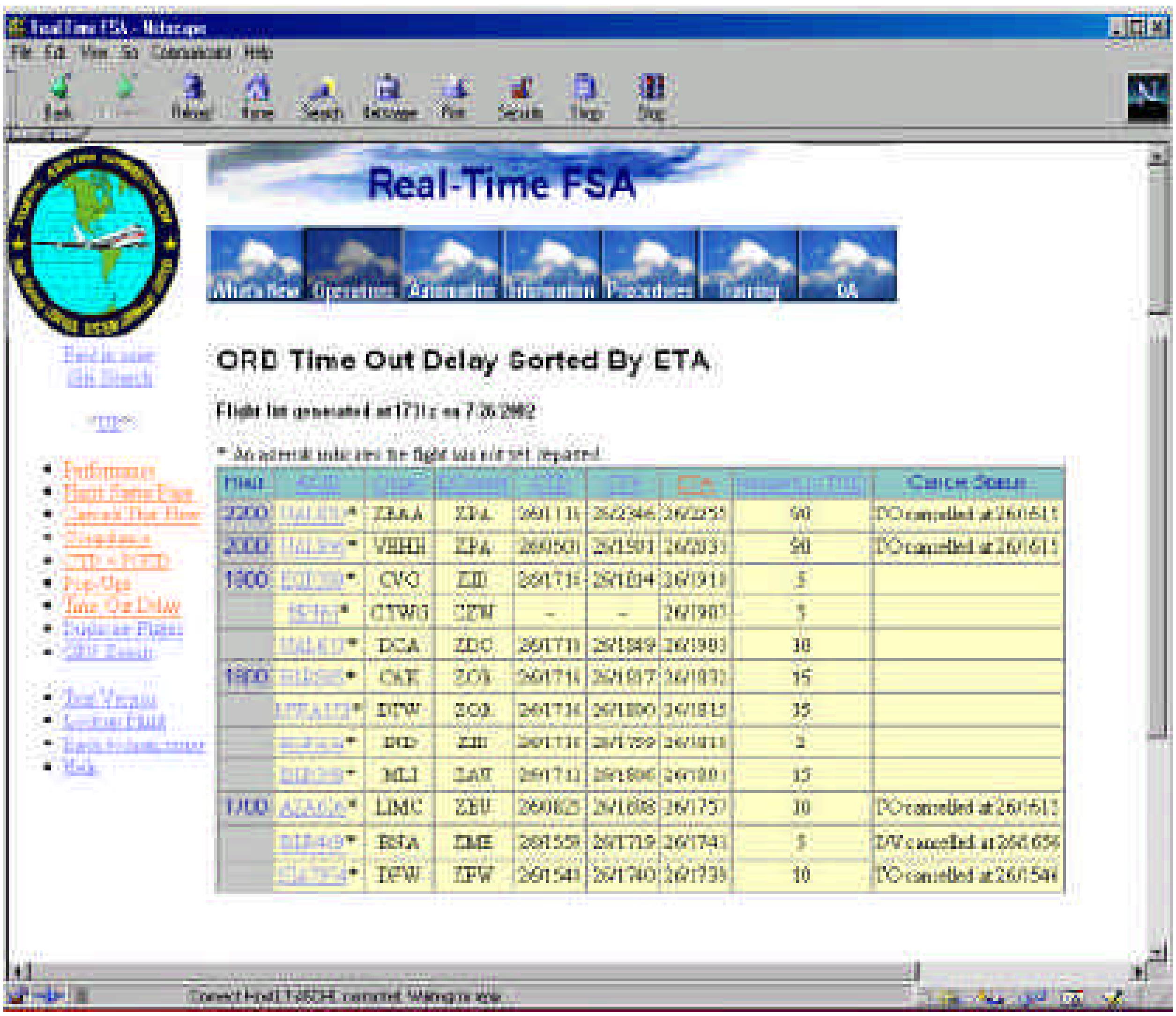
- Route Management Tool (RMT)
- Collaborative Routing Coordination Tool (CRCT)
- Pathfinder Web Page (PFWP)
- Reroute Programs

<u>System Impact Assessment</u>

System impact assessment tools provide "what-if" real-time decision support to mitigate the impact of a proposed TFM initiative. System impact tools include:

- Flow Constraint Area (FCA)
- Flow Evaluation Area (FEA)
- Real-Time Flight Schedule Analyzer (FSA), shown in Figure 9.

Figure 9. Real Time Flight Schedule Analyzer



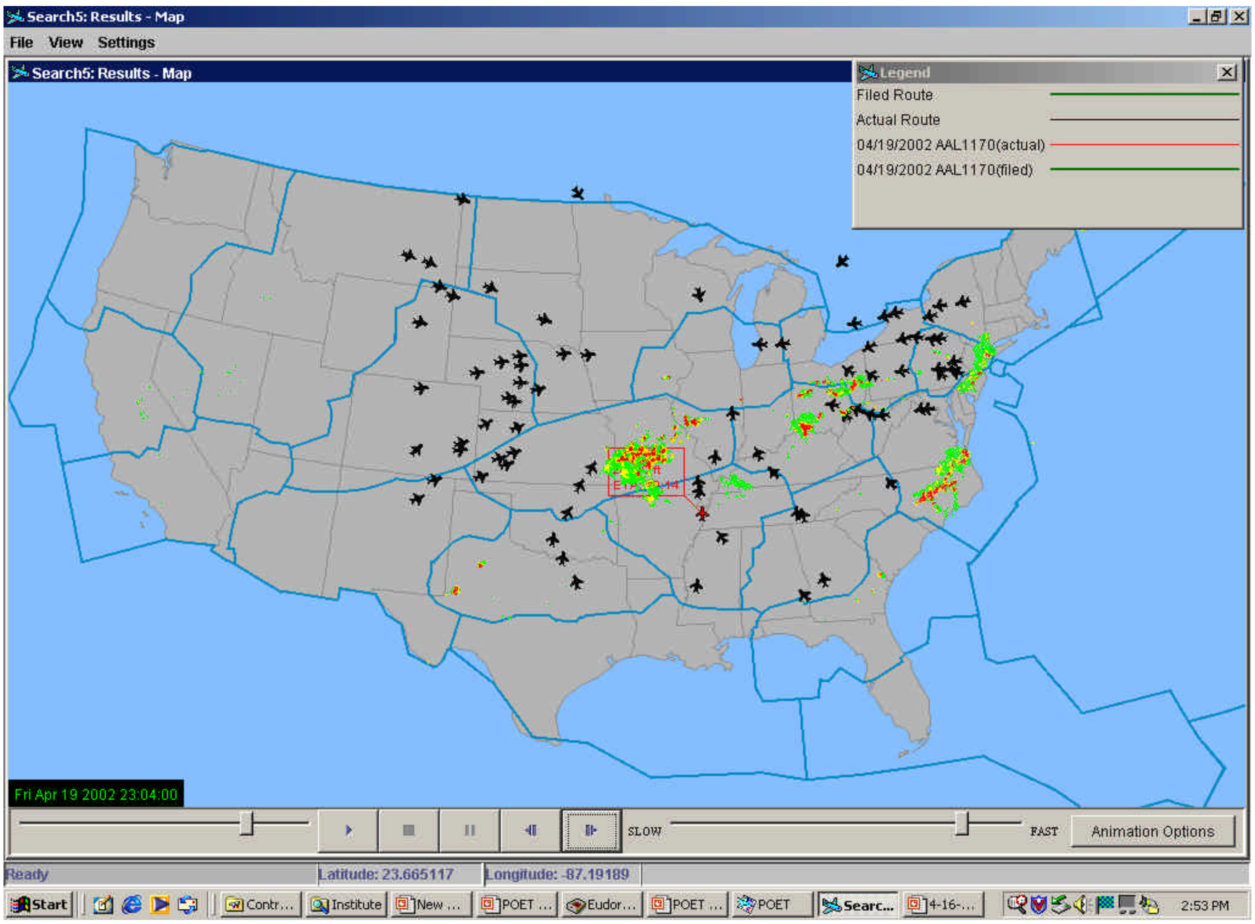
· Flight Schedule Monitor (FSM) Power Run

<u>Performance Assessment</u>

Performance assessment tools provide near-real-time post-operational data analysis capabilities. They include:

· Post – Operational Evaluation Tool (POET) shown in Figure 10.

Figure 10. Post – Operational Evaluation Tool



· Flight Schedule Analyzer shown in Figure 9.

Other procedures and capabilities employed by the ATCSCC include:

· National Severe Weather Playbook (Reference 4)

The National Playbook is a collection of Severe Weather Avoidance Plan (SWAP) routes that have been pre-validated and coordinated with impacted ARTCC's. The National Playbook is designed to mitigate the potential adverse impact to the FAA and users during periods of severe weather or other events that affect coordination of routes. These events include, but are not limited to, convective weather, military operations, communications, and other situations.

Sample plays from the Playbook (currently some 278 pages) are shown in Figures 11 and 12.

Figure 11. Sample Routes Covered by Playbook

EAST-TO-WEST TRANSCON ROUTES

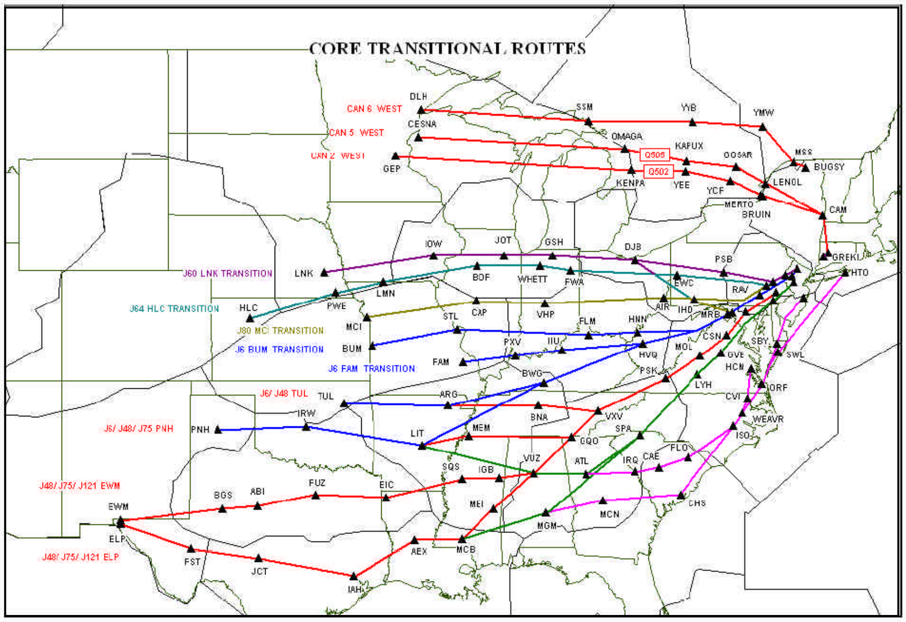


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Figure 12. Example from Playbook

CAN 2 WEST

Impacted Flow: ZNY/ZBW DEPARTURES TO 6WEST ARTCCs

Facilities Included: ZBW/ZNY/CZY/ZMP

SPECIAL NOTE: ONLY THE CORE ROUTING IS MANDATORY. NRP IS PERMITTED BEYOND THE CORE ROUTE EXIT POINT FIX. ATC SHALL NOT MODIFY ROUTE OF FLIGHT BEYOND THE CORE ROUTE EXIT POINT FIX IF THE FLIGHT PLAN IS SHOWING THE CORRECT CORE ROUTING.

SPECIAL NOTE: **THIS ROUTING REQUIRES AREA NAVIGATION CAPABILITY.**

FACILITY	CORE ROUTING	MIT	ALT	REMARKS
ZBW	CAM BRUIN MERTO Q502 KENPA GEP			
ZNY (NY METROS)	GREKI V419 JUDDS CAM BRUIN MERTO Q502 KENPA GEP			

DEFAULT ROUTE TO DESTINATION

DESTINATION	ROUTING FROM EXIT POINT	DESTINATION	ROUTING FROM EXIT POINT
SEA	GEP DIK MLP GLASR5 SEA	LAS	GEP FSD BFF EKR J100 BCE KSINO1 LAS
PDX	GEP ABR BIL J16 PDT BONVL4 PDX	SAN	GEP FSD BFF EKR J100 BCE J60 BLD TNP BARET4 SAN
SFO	GEP ABR J32 BOY BPI LCU J158 MVA MOD2 SFO	SLC	GEP ABR J32 BOY BPI LHO2 SLC
SJC	GEP FSD BFF EKR OAL HYP5 SJC	DEN	GEP ONL J114 SNY LANDR4 DEN
LAX	GEP FSD BFF EKR J100 BCE J60 HEC J64 CIVET CIVET4 LAX	PHX	GEP ONL ALS GUP BUNTR1 PHX

graphic: CAN_2_WEST

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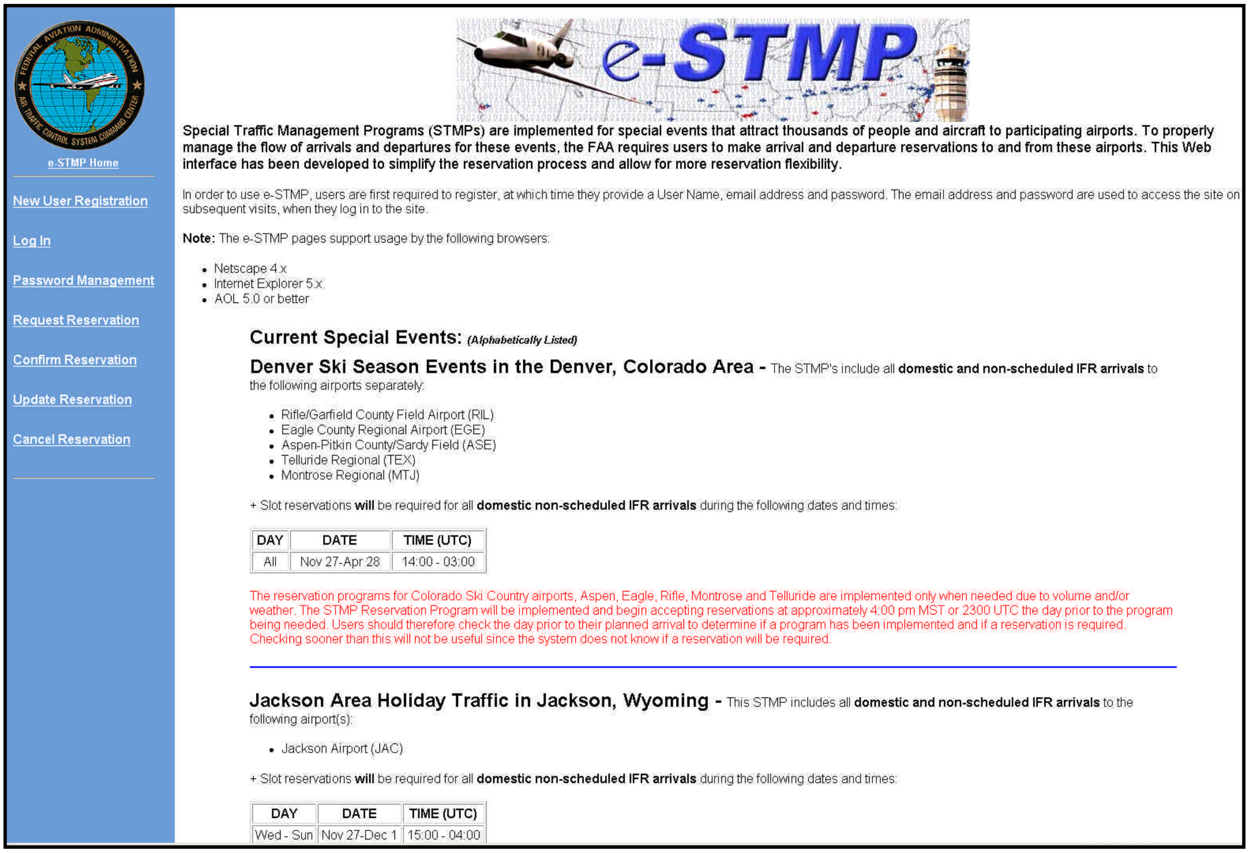
- Special Traffic Management Program (STMP) as shown in Figure 13
- Departure Spacing Program (DSP)

Figure 13. Special Traffic Management Program Example



3.2 Operational Policies and Constraints

The operational policies and constraints relevant to the present traffic management system are contained in References 4, 5 and 6.

3.3 Description of Current System or Situation

3.4 Users or Involved Personnel

In this section the focus is on the roles and responsibilities of each of the active participants in the present environment or situation. Users and involved personnel are identified in Table 1. Subsections address the roles and responsibilities of the Air Traffic Service Provider (ATSP) and the AOC respectively.

ATSP Roles and Responsibilities:

The ATSP roles and responsibilities are clearly outlined in FAA Order 7210.3S *Facility Operation and Administration* (Reference 5). To indicate the scope and nature of those roles and responsibilities, the outline of Part 5, Chapter 17 (Traffic Management National, Center, and Terminal) is reproduced below.

Section 1. Organizational Missions

Section 2. Organizational Responsibilities
Section 3. Line of Authority
Section 4.Supplemental Duties
Section 6. Enhanced Traffic Management System
Section 7. Monitor and Alert Parameter
Section 8. Traffic Flow Management
Section 9 Sequencing Programs
Section 10. Ground Delay Programs
Section 11. Ground Stops
Section 12. Special Traffic Management Programs
Section 13. Severe Weather Management
Section 14. Several Weather Avoidance Plan
Section 15. Preferred IFR Route Program
Section 16. Traffic Management Initiatives
Section 17. National Route Program
Section 18. Alternative Routings
Section 19. Strategic Plan of Operation
Section 20. National Playbook
Section 21. Traffic Management National Log
Section 22. Aviation System Performance Metrics

Pilot Roles and Responsibilities: The IFR aircraft pilot has responsibility for situation awareness flight planning/replanning and execution, and adherence to clearances/instructions issued by the ATSP.

AOC Roles and Responsibilities: The AOC dispatcher has the responsibility for scheduling company aircraft and for filing flight plans and amendments that are cooperatively developed with the pilot of the aircraft in question.

3.5 Support Strategy

To be determined

Table 1. Users/Involved Personnel for Current Operations

Users or Involved Personnel	Current Operations
Traffic Management Specialist at ATCSCC	✓
Air Traffic Control Supervisor (ATCS)	✓
Supervisory Traffic Management Coordinator-in-Charge (STMCIC)	✓
Operations Supervisors (OS)	✓
Traffic Management Coordinator (TMC)	✓
En Route Radar Position – R controller	
En Route Radar Associate (RA) – D controller	
En Route Radar Coordinator (RC)	
En Route Radar Flight Data (FD) Position	
En Route Non Radar (NR) Position	
Terminal Radar Position – R controller	
Terminal Radar Associate (RA) – D controller	
Terminal Radar Coordinator (RC)	
Terminal Radar Flight Data (FD) Position	
Terminal Non Radar (NR) Position	
Tower Local Controller (LC)	
Tower Ground Controller (GC)	
Tower Associate	
Tower Coordinator	
Tower Flight Data Position	
Tower Clearance Delivery Position	
Flight Service Station Specialist (FSSS)	
Airline or Aircraft Flight Operations Center (AOC)	✓
Pilot or Flight Crew (FC)	

4. Justification for and Nature of Change

4.1 Justification for Change

Recent TFM research by NASA Ames Research Center has resulted in a new modeling and simulation capability called Future ATM Concepts Evaluation Tool (FACET). FACET has been provided to the FAA, industry, small companies, and universities and appears to hold promise for use as a pre-emptive TFM tools at AOCs. It has also been identified as a candidate for further development as a congestion management tool for the ATCSCC and TMUs.

In 2002, NASA worked with the ATCSCC and AOCs to refine requirements for such tools and to demonstrate with a SWEPT proof-of-concept version. The exact nature of the tools and the specific TFM problem areas for its application is not yet determined.

4.2 Description of Needed Changes

To be determined

4.3 Priorities Among the Changes

To be determined

4.4 Changes Considered But Not Included

To be determined

4.5 Assumptions and Constraints

This section describes the assumed operational conditions under which SWEPT will be applied. The operational environment includes the airspace structure, routes within this structure, and their constraints; the mix of aircraft types, their equipment, and performance limits; the weather and visibility conditions; the Communications, Navigation, and Surveillance (CNS) infrastructure within the airspace that enable connecting the flight crew (FC) with ATSP; and the ATM capabilities environment. Each of these elements is discussed from the point of view of representing the range of environments that need to be considered.

Airspace Structure and Route Constraints: No changes from today

Traffic Mix and Equipage: No changes from today.

CNS Infrastructure: No changes from today.

ATM Environment: No changes anticipated.

5. Concept for a New or Modified System

5.1 Background, Objectives, and Scope

SWEPT represents the next generation of TFM decision support tools (DSTs) that will improve the capabilities of the ATCSCC and TMUs to evaluate traffic flow management problems and initiatives that could be implemented to ameliorate such problems. The exact objectives and scope of SWEPT are not yet established, but they include:

- Support TFM specialists in the identification of effective TFM initiatives to alleviate predicted throughput problems associated with severe weather.
- Monitor current/proposed initiatives to determine effectiveness and identify when modifications may be necessary.
- Support the development of initiative modifications, when required.
- Analyze previously implemented initiatives to determine causes of ineffectiveness.
- Support the development of new approaches to handling severe weather.

5.2 Operational Policies and Constraints

The operational policies and constraints relevant to the present traffic management system are contained in References 5, 6, and 7. Some might have to be modified based upon the changes SWEPT introduces.

5.3 Description of the New or Modified System

SWEPT is in a preliminary definition phase, and as such, a clear statement of its capabilities cannot be put forward. However, a number of capabilities are under discussion and prototype development that will help better define its capabilities by 2004. The description here is a collection of *potential* capabilities that SWEPT might possess.

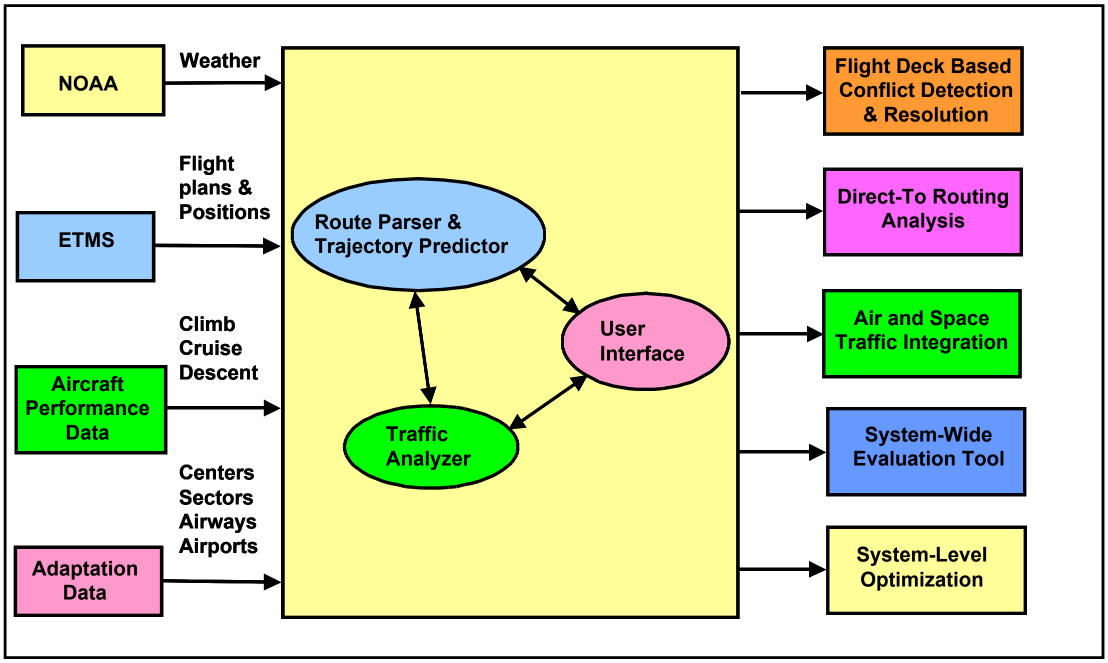
Regardless of what capabilities are ultimately defined for SWEPT, FACET will provide much of the underlying capabilities so a summary of FACET is provided here.

FACET is a simulation tool built for exploring advanced ATM concepts. It provides a flexible environment for rapid prototyping of new ATM concepts. FACET interfaces with the Host and ETMS data and can be integrated with other tools of varying complexity and fidelity.

FACET provides a balance between fidelity and flexibility. It can be used to model airspace operations at a U.S. National level (up to 5,000 aircraft airborne at any one time), has a modular architecture for flexibility, is written in “C” and “Java” programming languages that are easily adaptable to different computer platforms such as Sun, Silicon Graphics, PCs, and MACs, and can be used for both off-line analysis and real-time applications.

Figure 14 shows the currently defined FACET Architecture.

Figure 14. Current FACET Architecture



FACET provides the following capabilities:

Weather Models: Weather models include winds aloft (Rapid Update Cycle (RUC)) and convective cells forecasts (NOAA).

4D Flight Plans and Trajectories: 4D trajectory modeling capabilities, including a global co-ordinate system; the ability to fly flight-plan routes or direct (great circle) routes over round earth; it includes (ETMS data plus Trajectory Predictor)

Airspace Modeling: Modeling of en route airspace over the entire continental U.S., including center and sector boundaries; Special Use Airspace boundaries; Jet Routes and Victor Airways, and locations of navaids and airports (Adaptation Data)

Aircraft Models: Climb/descent performance models for 66 aircraft types, mapped to over 500 aircraft types with dynamic models for turns and acceleration/deceleration. New classes of vehicles (e.g., space launch vehicles) can easily be added. (Aircraft Performance Data)

Visualization: Visualization is useful to provide a deeper understanding of current-day operations and new operational concepts. The capabilities include 2 and 3 D traffic displays (Figures 15 and 16); display of real-time weather overlay on national traffic flow; spatial distribution of congested sectors (Figure 17); and aircraft usage of sectors (Figure 18)

Traffic Flow Management Strategies: FACET can evaluate the impacts of airspace restrictions (Figures 19 and 20); delays associated with miles-in-trail restrictions, and the impacts of alternative restrictions (see Figure 21).

Figure 15. Prototype SWEPT Graphical User Interface

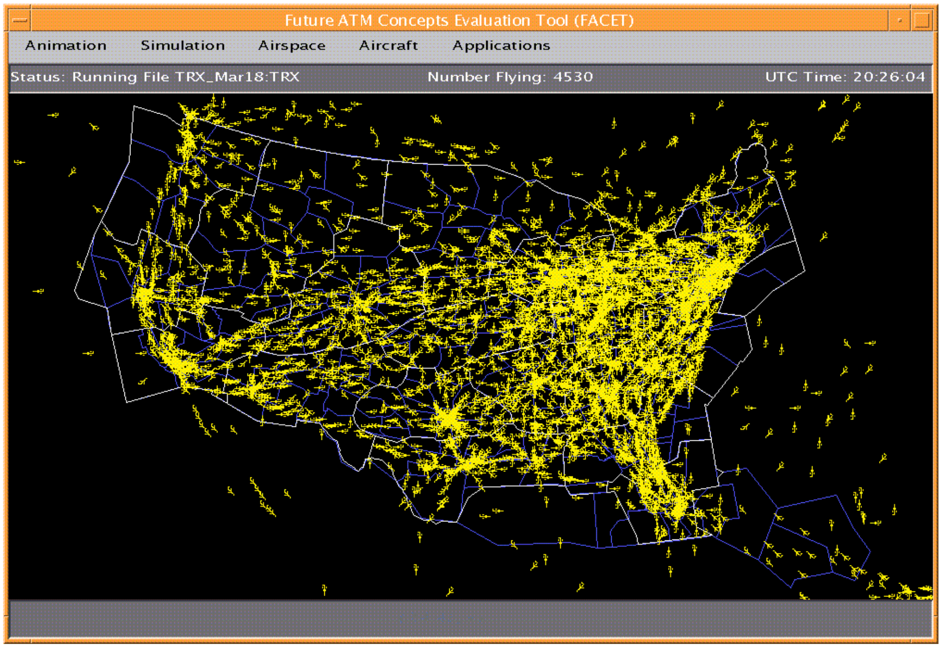
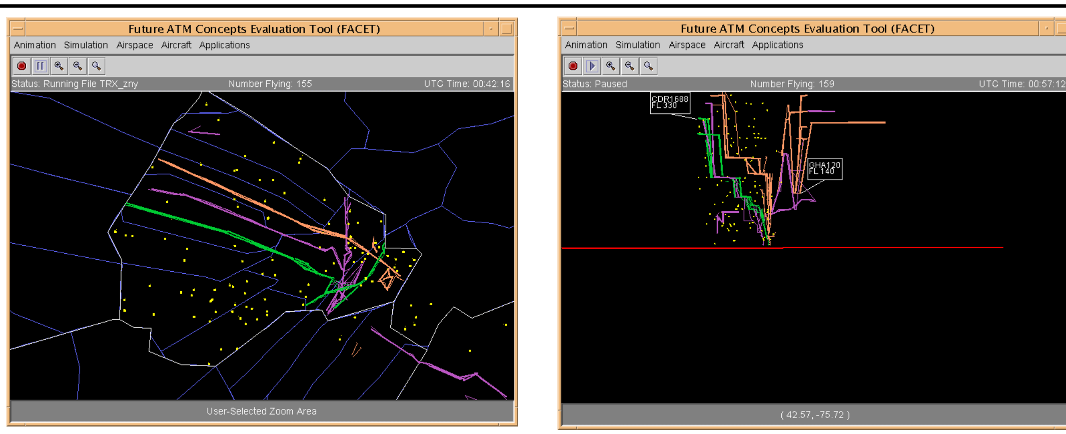


Figure 16. 2D and 3D ZNY Traffic Display



Arrivals into EWR, LGA and JFK highlighted.

Figure 17. Spatial Distribution of Congested Sectors

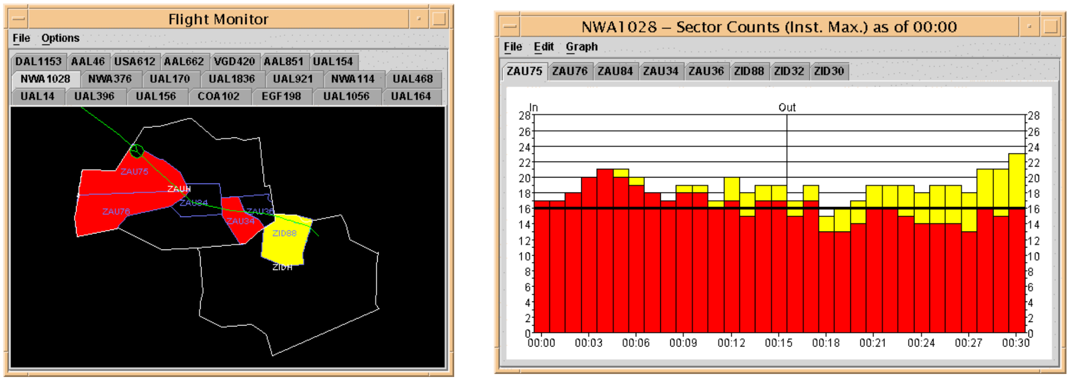
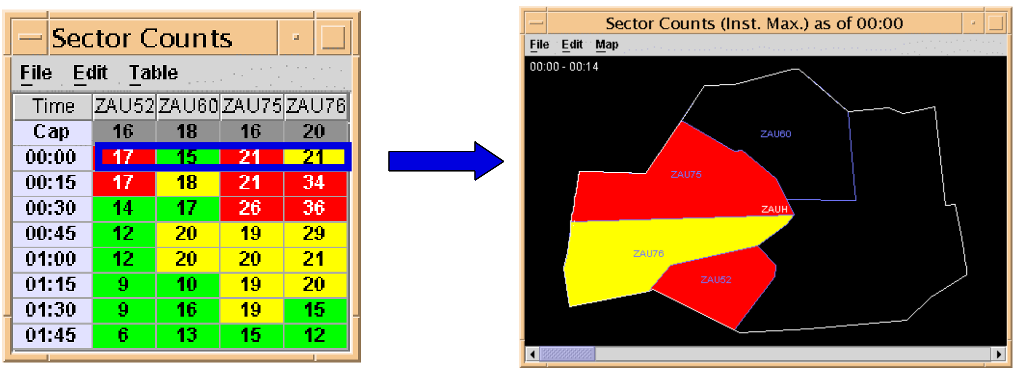
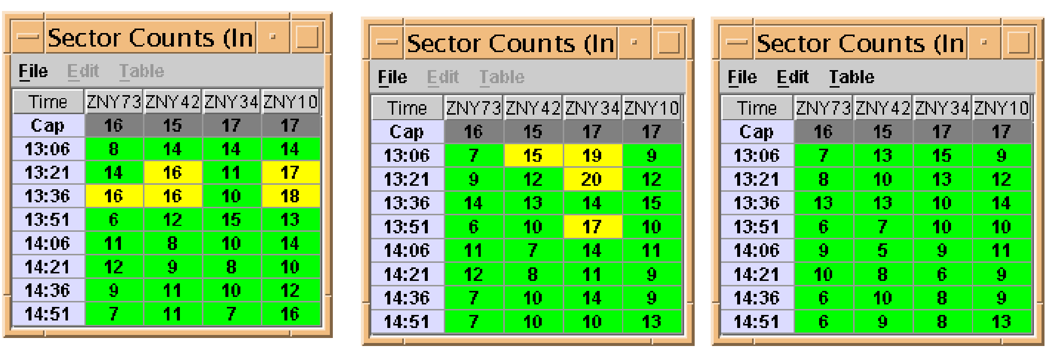


Figure 18. Aircraft Usage of ZAU75



Time	ZAU52	ZAU60	ZAU75	ZAU76
Cap	16	18	16	20
00:00	17	15	21	21
00:15	17	18	21	34
00:30	14	17	26	36
00:45	12	20	19	29
01:00	12	20	20	21
01:15	9	10	19	20
01:30	9	16	19	15
01:45	6	13	15	12

Figure 19. Impact of Rerouting and Departure Delays on ZNY



Time	ZNY73	ZNY42	ZNY34	ZNY10
Cap	16	15	17	17
13:06	8	14	14	14
13:21	14	16	11	17
13:36	16	16	10	18
13:51	6	12	15	13
14:06	11	8	10	14
14:21	12	9	8	10
14:36	9	11	10	12
14:51	7	11	7	16

Time	ZNY73	ZNY42	ZNY34	ZNY10
Cap	16	15	17	17
13:06	7	15	19	9
13:21	9	12	20	12
13:36	14	13	14	15
13:51	6	10	17	10
14:06	11	7	14	11
14:21	12	8	11	9
14:36	7	10	14	9
14:51	7	10	10	13

Time	ZNY73	ZNY42	ZNY34	ZNY10
Cap	16	15	17	17
13:06	7	13	15	9
13:21	8	10	13	12
13:36	13	13	10	14
13:51	6	7	10	10
14:06	9	5	9	11
14:21	10	8	6	9
14:36	6	10	8	9
14:51	6	9	8	13

Nominal Sector Counts

NO_WESTGATES Rerouting

NO_WESTGATES + EWR and LGA Departure Delays

Figure 20. Impact of Rerouting and Departure Delays by Airline

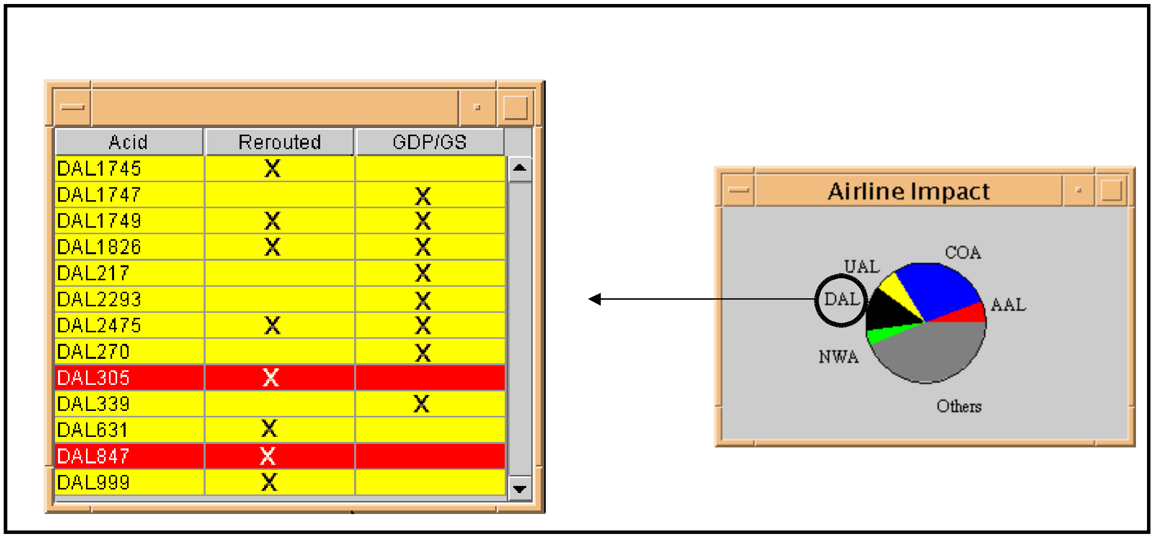
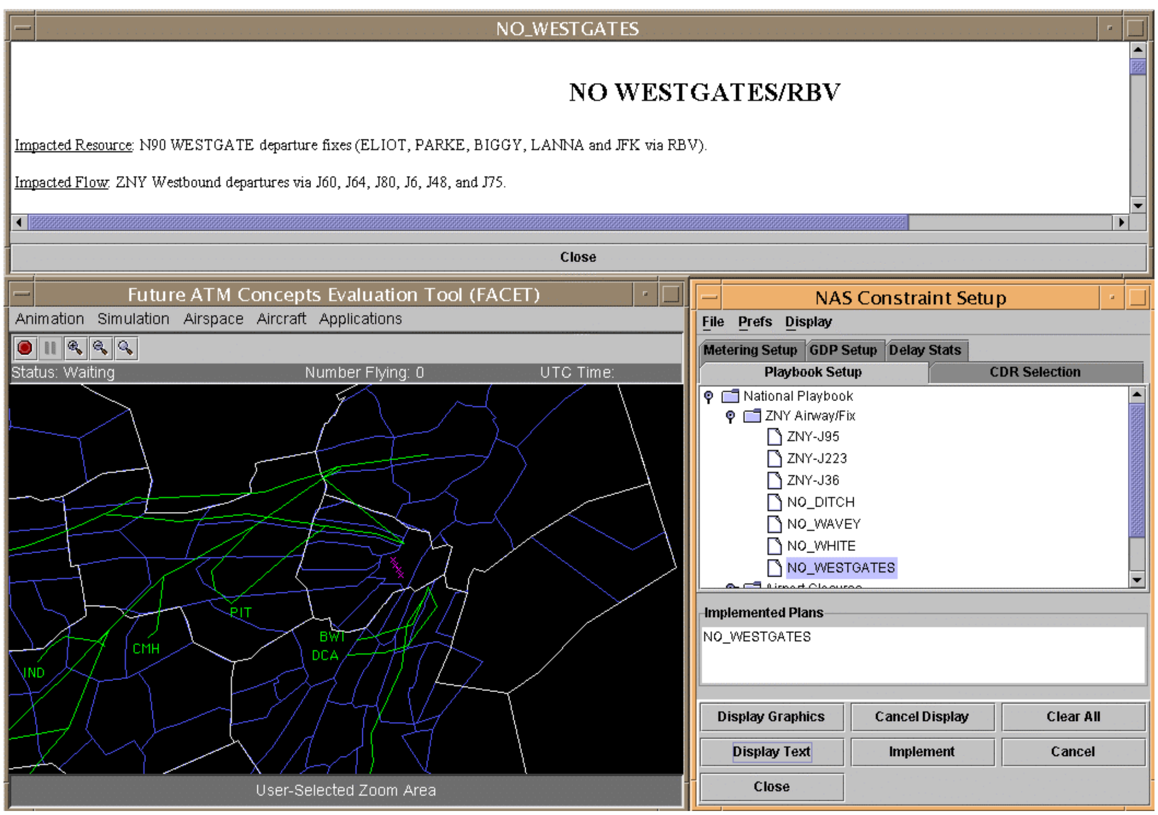


Figure 21. No WESTGATES/RBV Playbook Plan



SWEPT will have three modes of operation: Real-Time, Off-Line, and Research.

SWEPT Real-Time Mode: In real-time mode, the objective is to support ATCSCC and local TFM specialists in the development and monitoring of TFM initiatives. Some capabilities include:

- Connectivity to ETMS for static (boundaries, waypoints, etc.), dynamic (tracks, flight plans, etc.), weather (CCFP, etc.), and TFM advisory information.
- Monitoring of aircraft conformance with active advisories to identify impediments to initiative effectiveness. This capability will permit the ATCSCC to monitor the conformance of traffic flows to plays that have been initiated from the National Severe Weather Playbook and evaluate the effectiveness of such plays in alleviating traffic flow constraints. The ATCSCC will be able to determine which airline/aircraft are impacted by a play (or multiple initiatives) and how such airlines/aircraft are conforming to the desired actions.
- Planning capabilities (including simulation) to determine effective initiative modifications to alleviate impediments.

SWEPT will have alternative ways of representing congestion data taking into account relevant metrics and measures. It may integrate other TFM tools (e.g., FSM, POET, and DSP).

This mode will also serve as a hardware/software platform for developing additional real-time analysis and monitoring capabilities for the ATCSCC and TMUs.

SWEPT Off-Line Mode: In off-line mode, the objective is to analyze previous day initiatives for quality assurance. Some capabilities include:

- Performing fast-time playback of previous day situations with analysis capabilities to determine causes of initiative ineffectiveness.
- Simulation capability to try determine the effectiveness of alternate initiatives during these situations.
- Statistics generation to support reporting requirements.

SWEPT may have a capability to develop and evaluate new flow management procedures and methods using a flexible simulation environment build upon the FACET capabilities. It will have a number of submodes of operation that are yet to be determined. They may include:

- A training capability
- A real-time database of predicted trajectories to complement ETMS historical databases.

SWEPT Research Mode: It is desirable that researchers at NASA and the FAA have a SWEPT-like capability in order to support research into improve TFM tools. A Research Mode for SWEPT will represent that capability. It will support rapid prototyping and integration of any new tools into the operational SWEPT.

5.4 Users/Affected Personnel

In this section, the roles and responsibilities of the ATSP and AOCs for SWEPT operations are summarized. Details of the roles and responsibilities will have to await further definition of SWEPT.

ATSP Roles and Responsibilities: SWEPT will not impact air traffic controllers. It will mainly impact air traffic managers and coordinators at the ATCSCC and TMUs.

Pilot Roles and Responsibilities: SWEPT will cause no change in flight deck/pilot activities

AOC Roles and Responsibilities: SWEPT will cause few changes in AOC operations. However, the technologies behind SWEPT (e.g., FACET) may be used by AOCs to improve the effectiveness of their TFM tools. In that case, there may be some interation between an AOC tool and SWEPT.

Table 2 identifies all potential users or involved personnel, based upon SWEPT operations. It is identical to Table 1. The users involved before and after SWEPT are the same. Their roles and responsibilities change in accordance with the preceding discussion.

Table 2. Users or Personnel Involved in SWEPT Operations

Users or Involved Personnel	SWEPT Operations
Traffic Management Specialist at ATCSCC	✓
Air Traffic Control Supervisor (ATCS)	✓
Supervisory Traffic Management Coordinator-in-Charge (STMCIC)	✓
Operations Supervisors (OS)	✓
Traffic Management Coordinator (TMC)	✓
En Route Radar Position – R controller	
En Route Radar Associate (RA) – D controller	
En Route Radar Coordinator (RC)	
En Route Radar Flight Data (FD) Position	
En Route Non Radar (NR) Position	
Terminal Radar Position – R controller	
Terminal Radar Associate (RA) – D controller	
Terminal Radar Coordinator (RC)	
Terminal Radar Flight Data (FD) Position	
Terminal Non Radar (NR) Position	
Tower Local Controller (LC)	
Tower Ground Controller (GC)	
Tower Associate	
Tower Coordinator	
Tower Flight Data Position	
Tower Clearance Delivery Position	
Flight Service Station Specialist (FSSS)	
Airline or Aircraft Flight Operations Center (AOC)	✓
Pilot or Flight Crew (FC)	

6. Operational Scenarios

In the following discussion, we illustrate three conditions of SWEPT operation – nominal, rare-nominal, and failure. Each is defined, and narrative scenarios are used to describe the interplay between FC and ATSP during the operational process.

Normal or Nominal Condition: The normal, or nominal, condition for SWEPT is where all air and ground systems function as expected under normal conditions, traffic is in a steady state condition in terms of approach airspace used, routes and zones are not blocked by weather cells, and the runway in use is not changing.

To be determined

Rare-Nominal Condition: The rare-nominal conditions for SWEPT exist when unusual weather (such as a preponderance of storm cells blocking nominal approach routes or zones) occurs, a runway change takes place, or there is a disruption of a string because of a missed approach or a FC that is not maintaining proper positioning. In the following scenario, a major weather cell blocks the nominal approach zone so that the participating aircraft must be diverted and merged with traffic within a different approach zone.

To be determined

Failure Condition: The failure conditions for SWEPT are those events where equipment fails, human errors disrupt normal operation, or operational conditions abruptly change so that nominal or rare-nominal operation cannot continue. Each of these conditions needs to be defined and analyzed so that safe recovery processes can be developed which revert to a more manual traffic management process. In the following scenario, a surveillance failure causes a major disruption.

To be determined

7. Summary of Impacts

7.1 Operational Impacts

The NAS operational impacts, including planned NAS architecture components, of the SWEPT are discussed in the following paragraphs. The following changes from the NAS 4.0 mature baseline, expressed in terms of technology and infrastructure, are needed to support the concept. These are described in the area of Communications, Navigation, Surveillance, Automation, Weather, and Traffic Management.

Communications: No change

Navigation: No change

Surveillance: No change

Automation: No change

Weather: No change

Traffic Management:

To be determined

7.2 Organizational Impacts

To be determined

7.3 Impacts during Development

SWEPT is at a very early stage of development. As such, it is difficult to determine the impacts on the user, acquirer, and maintenance organizations during development. It is however required that FAA Air Traffic Managers participate in the development process during demonstration and test phases.

8. Analysis of the Proposed System

8.1 Summary of Advantages

The following is a list of the potential benefit mechanisms from SWEPT, discussed in the context of the metrics associated with AATT goals of:

Capacity: The capacity-related potential benefits of SWEPT service are as follows:

To be determined

Flexibility: The following flexibility-related potential benefits of SWEPT have been identified:

To be determined

Flexibility:

To be determined

Efficiency: The following efficiency-related potential benefits for SWEPT have been identified. These are separated into benefits to Users/FCs and to the ATSP.

To be determined

Predictability: The following predictability-related potential benefits of SWEPT have been identified.

To be determined

Safety:

To be determined

Access: The following access-related potential benefits for SWEPT have been identified. This refers to the ability of FCs to obtain access to airport, airspace, and ATC services.

To be determined

Environment: The following environmental potential benefits of SWEPT have been identified:

To be determined

Scalability: The following scalability-related potential benefits of SWEPT have been identified. Scalability refers to the capability of the air traffic system to continue to operate successfully with continually increasing traffic volumes. Scalability has two aspects, operational and economic.

To be determined

Economy:

To be determined

8.2 Summary of Disadvantages/Limitations

To be determined

8.3 Alternatives and Tradeoffs Considered

To be determined

9. Notes

Abbreviations and Acronyms

AATT	Advanced Air Traffic Technologies
ADC	Airport Demand Chart
AOC	Airline Operations Center
ARTCC	Air Route Traffic Control Center
ATCSCC	Air Traffic Control System Command Center
ATM	Air Traffic Management
ATSP	Air Traffic Service Provider
CCFP	Collaborative Convective Forecast Product
CCSD	Common Constraint Situation Display
CDM	Collaborative Decision Making
CDRL	Contract Deliverable Requirements List
CNS	Communications, Navigation, and Surveillance
CRCT	Collaborative Routing Coordination Tool
DRWP	Diversion Recovery Web Page
DSP	Departure Spacing Program
DST	Decision Support Tool
ESIS	Enhanced Status Information System
ETMS	Enhanced Traffic Management System
EWR	Newark International Airport
FAA	Federal Aviation Administration
FACET	Future ATM Concepts Evaluation Tool
FC	Flight Crew
FEA	Flow Evaluation Area
FCA	Flow Constraint Area
FSA	Flight Schedule Analyzer
FSM	Flight Schedule Monitor
GDP	Ground Delay Programs
IEEE	Institute of Electrical and Electronic Engineers
IFR	Instrument Flight Rules
JFK	J.F. Kennedy International Airport
LGA	LaGuardia Airport
M/A	Monitor/Alert
MAC	Apple Macintosh Computer
MSL	Mean Sea Level
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
OCD	Operational Concept Description
PC	Personal Computer
PFWP	Pathfinder Web Page
POET	Post – Operational Evaluation Tool
RMT	Route Management Tool
RUC	Rapid Update Cycle

RVR	Runway Visual Range
STMP	Special Traffic Management Program
SWAP	Severe Weather Avoidance Plan
SWEPT	System Wide Evaluation and Planning Tool
TFM	Traffic Flow Management
TM Log	Traffic Management Log
TMC	Traffic Management Coordinator
TMS	Traffic Management System
TMU	Traffic Management Unit
TRACON	Terminal Radar Control
TSD	Traffic Situation Display
WSD	Web-Based Situation Display
ZNY	New York Center